Report for 2005MS29B: Analysis of Stream Bank Erosion by Lateral Ground Water Flow

Publications

- Water Resources Research Institute Reports:
  - Fox, Garey, 2006, Analsis of Stream Bank Erosion by Lateral Ground Water Flow, Mississippi Water Resources Research Institute, Mississippi State University, Mississippi State, MS, 18 pages.
- Conference Proceedings:
  - Fox, Garey, G. Wilson, R. Periketi, and R. Cullum, 2005, Developing a sediment transport model for the seepage erosion of streambank sediment. In Proceedings of the American Water Resources Conference, Nov 7-10th, 2005, Seattle, WA, 4 pages (CD-ROM).
  - Fox, Garey, G. Wilson, R. Periketi, L. Gordji, and R. Cullum, 2005, The Role of Subsurface Water in Contributing to Streambank Erosion. Proceedings of the US-China Workshop on Advanced Computational Modeling in Hydroscience and Engineering, August 2-5, 2005, Oxford, Mississippi, USA, 10 pages (CD-ROM).
- Articles in Refereed Scientific Journals:
  - Fox, Garey, G. Wilson, R. Periketi and B.F. Cullum, 2006, A sediment transport model for seepage erosion of streambanks. Journal of Hydrologic Engineering – ASCE (Accepted May 1, 2006, HE/2005/022923).

Report Follows

ANALYSIS OF STREAM BANK EROSION BY LATERAL GROUND WATER FLOW

FINAL TECHNICAL REPORT

PI: Garey Fox, Ph.D.
University of Mississippi
Department of Civil Engineering

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ABSTRACT

Subsurface flow is known to contribute significantly to stream flow but its contribution to streambank failure, a process which may contribute significantly to sediment loading in streams, is not well known. Research is needed in understanding the contribution of concentrated, lateral subsurface flow to streambank failure and the hydraulic properties controlling seepage erosion. Laboratory experiments were conducted with two-dimensional soil lysimeters to observe subsurface flow induced erosion of bank faces under controlled conditions. Experiments were performed with single-layer sediment and also layered profiles to mimic streambanks where seepage erosion has been observed. The lysimeter experiments were compared to in-situ measurements of seepage discharge and erosion at field sites in Northern Mississippi. The soil and hydraulic conditions controlling seepage erosion were investigated. Changes in soil water pressure were monitored and modeled using a two-dimensional variably-saturated flow code to deduce information regarding soil water pressures at the time of bank failure and tension crack formation. A seepage erosion sediment transport model is proposed for the long-term goal of incorporation into a combined bank stability/ground water flow models for predicting streambank failure by seepage.

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INTRODUCTION

There exists an incomplete understanding of one of the basic mechanisms governing sediment loading to streams by streambank failure: erosion by concentrated lateral, subsurface flow. This research hypothesizes that erosion by subsurface flow is important in promoting stream bank failure and sediment loading to streams in numerous geographical locations. Subsurface flow is known to contribute significantly to stream flow. Flow through large macropores or pipes, commonly referenced to as pipeflow (Jones, 1997), can cause subsurface flow to dominate overland flow in some catchments. High infiltration rates can cause the development of perched water tables above water-restricting horizons in riparian soils (Wilson et al., 1991). As perched water tables rise on these less permeable layers, large hydraulic gradients can initiate towards stream channels, causing fairly rapid subsurface flow (interflow or throughflow) to streams (Figure 1). Hagerty (1991a, 1991b) reports that even seemingly slight changes in soil texture can result in considerable hydraulic conductivity contrasts between layers and form perched water tables in layered soils. Subsurface flow over perched water tables can contribute in gully formation, as shown in Figure 2 (Istanbulluoglu et al., 2005; Bryan, 2000; Romkens et al., 1997; Froese et al., 1999). Shallow subsurface flow plays a critical role in erosion in interacting with surface runoff mechanisms.

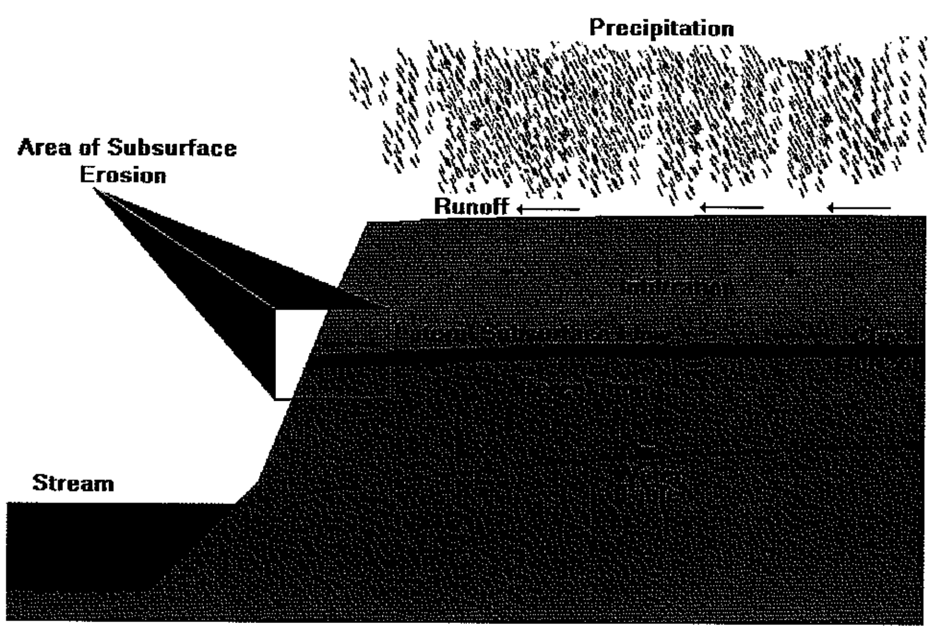

Figure 1 - Depiction of subsurface flow erosion mechanism of infiltrated water flowing in perched water tables in riparian zones adjacent to streams. Source: Fox et al. (2006).

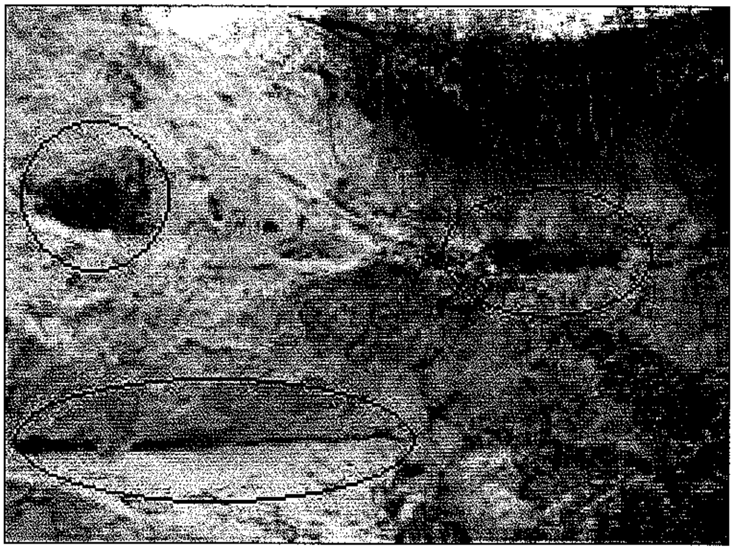

Figure 2 - Example of typical liquefaction of streambank sediment and headward migration of gully face along Little Topashaw Creek (LTC) in Northern Mississippi.

Research has begun to investigate the interaction of surface erosion, fluidization, and slumping whereby the onset of erosion was controlled not only by surficial flows but also hydrodynamic stress from groundwater seepage (Lobkovskey et al., 2004; Jones, 1997). Indoor flume studies indicate that surface erosion rates increase by an order of magnitude when groundwater increased unsaturated pore-water pressures thereby decreasing soil shear strength (Rockwell, 2002; Owoputi and Stolte, 2001). Most researchers investigating the role of seepage on erosion and undermining of hillslopes have focused on the seepage pressure as a body force acting on some representative sediment volume (Howard and McLane, 1988; Iverson and Major, 1986). Iverson and Major (1986) analyzed the physical effects of groundwater seepage on slope stability. They proposed that the force vector proportional to the hydraulic gradient is responsible for hillslope failure (Iverson and Major, 1986). Howard and McLane (1988) suggested that surface grains of cohesionless sediment eroded by groundwater are acted upon by three forces: gravity, a traction force defined as the sum of all forces on the seepage face, and a seepage force exerted on the sediment grain by groundwater seepage. Seepage forces predominate in a narrow "sapping zone" at the flow discharge, and erosion occurs by bulk sediment movement in this zone. Howard and McLane (1988) expressed the seepage force (F_s) and tractive force (F_t) as:

layer at the bottom and a 10 cm thick LS layer. The small lysimeter utilized a 40 cm SiL topsoil layer. Two SiL layer thicknesses were investigated in the large lysimeter: 50 cm and 80 cm. Before the start of the experiments, the lysimeters were saturated for 24 hours to achieve a consistent antecedent moisture condition. Following the 24 hour period, the lysimeters were drained for 24 hours to achieve field capacity. Two cameras were installed to monitor the experiments. One camera captured the front view of the lysimeters and another camera captured the discharge end of the lysimeters focused on the LS layer. Water was added to the inflow reservoir to achieve the desired head. The time water first discharged through the LS layer into the outlet flume was recorded. As the LS layer eroded and the undercutting occurred, flow and sediment samples were collected in sampling bottles at regular intervals. The undercutting of the LS layer was recorded by measuring the distance of undercutting from the end of the lysimeter. Experiments were performed until bank collapse occurred. In total, two experiments were performed for the single noncohesive soil layer with a constant inflow water head of 30 cm, horizontal lysimeter, and vertical bank face. Eleven lysimeter experiments were performed with reconstructed LTC streambank profiles by varying the inflow water head (30, 40, 60, or 90 cm), bank height of SiL (40 cm, 50 cm or 80 cm), and lysimeter slope (0%, 5%, or 10%). The bank face was cut to vertical for the 5 and 10% slopes. Discharge and sediment concentrations measured during seepage erosion in the lysimeter experiments were used to derive a sediment transport model that related discharge over perched water tables to sediment discharge.

Objective 3: Modify an existing conceptual model for stream bank instability to include the effects of erosion by lateral, subsurface flow

Initial bank stability modeling was performed during the reporting period; however, the third objective of the original proposal (i.e., modify an existing conceptual model for stream bank instability) was not accomplished during the reporting period. The PI and collaborators are continuing to work on development of such a model that incorporates the theoretical developments on seepage erosion described in this report. It is expected that development of a combined streambank stability and seepage erosion model will be released in the next two years.

The USDA-ARS Streambank Stability model (Simon and Curini, 1998; Simon and Thomas, 2002) was run for the lysimeter morphology using default properties for the materials. The friction angle, ϕ, and maximum angle, θ_c, were set to 15^o and 25^o, respectively. Measured soil water pressures for the top soil and restrictive layer were used and the water pressure imposed upon the conductive layer was varied to determine the impact of variable heads of water perched within the conductive layer. As an alternative to using measured soil water pressures with depth, the model was run by varying the depth of the static water table with the water pressures in the soil profile set to be in equilibrium with the water table (Wilson et al., 2006).

RESULTS AND DISCUSSION

Bank Characterization

Soil bank profiles were generally described as a thick (1.5 m) surface layer of silt loam (SiL) material that transition into a sandy loam (SL) from 1.5 to around 2 m depth (data not shown). The profile below this depth generally exhibited a sequence of alternating thin (10-15 cm) layers of contrasting texture reflecting the alluvial deposition. The samples taken in the conductive layer over restrictive layer seeps revealed the conductive layer to be a loamy sand (LS) with over 85% sand made up of predominately (98%) medium to very fine sand. The restrictive layer below had only a 16% increase in clay content such that the actual texture was a loam (L). Hagerty (1991a) reports that even seemingly slight changes in soil texture can result in considerable hydraulic conductivity contrasts between layers. This was clearly seen at these seeps as the saturated hydraulic conductivity decreased by two and a half orders of magnitude for the LS (1.4×10^3 cm d^{-1}) to the L (5.4 cm d^{-1}), Table 1.

Table 1 - Soil properties determined at selected seep locations.

Texture	Sand	Clay	Bulk Density	K_s	θ_s	θ_r	α	n
	%	%	g cm^{-3}	cm d^{-1}	$cm^3\ cm^{-3}$	$cm^3\ cm^{-3}$	cm^{-1}	
SiL	33	15	1.39	63.9	0.39†	0.06 †	0.006 †	1.6 †
LS	87	5	1.50	1453.1	0.40	0.03	0.012	2.0
L	39	21	1.61	5.4	0.44	0.05	0.009	1.7

K_s is the saturated hydraulic conductivity, θ_s is the saturated water content, and θ_r is the residual water content, and parameters, α, and n coincide with the van Genuchten water retention model with the Mualem approach. SiL is silt loam, LS is loamy sand, and L is loam.

† These values were derived from the pedotransfer function developed by Schaap et al. (1998) based upon the measured sand, silt, clay and bulk density.

In Situ Measurements

Seepage erosion was observed on several occasions at eight seeps along a 800 m reach of the LTC following storm events (Table 2, two seeps not listed). One of the seeps occurred as preferential flow through an open crack in a thick clay layer and another seep appeared to be preferential flow through a crack that was filled with silt loam material translocated from layers above. The remaining seeps occurred as subsurface flow through a conductive layer above a water restrictive layer.

Table 2 - Flow and sediment concentration characteristics of seeps along LTC.

			Sediment Concentration ($g\ L^{-1}$)			Flow Rate ($L\ d^{-1}$)		
Seep	Description†	n	Mean	Max	Min	Mean	Max	Min
1	LS over restrictive layer	5	50.1	138.1	0.4	110	317	17
2	LS over restrictive layer	7	472.1	659.4	294.0	187	330	119
3	LS over restrictive layer	4	96.5	205.1	3.5	142	239	34
4	silt filled fracture	4	369.0	642.9	137.5	111	203	9
5	open fracture	4	10.8	21.4	2.1	462	931	35
6	SiL over restrictive layer	5	96.8	388.1	1.1	68	175	4

n is the number of measurements made with time, LS is Loamy Sand, and SiL is Silt Loam.
† Textures were estimated in the field by the feel method.

Measurements of seep flow and sediment concentrations were made on multiple occasions between February and July of 2003 (Table 2). Due to the hazardous conditions of measuring seepage erosion from unstable banks, measurements were made between two to five days following rainfall events depending upon the magnitude of the event causing the subsurface flows. Therefore, these seepage measurements may under-estimate the flow rates and thus the seepage erosion rates experienced during storms.

Overall, seepage flow rates ranged by two and a half orders of magnitude (4 to 931 L d^{-1}) with an average of 174 L d^{-1} and a coefficient of variation (CV) of 119%. Seeps (1-3), characterized as flow through a conductive layer over a restrictive layer, had similar flow rates that averaged 152 L d^{-1} and the lowest variability of the different type seeps (CV=62%). The seep (5) through an open fracture exhibited the highest flow rates averaging 462 L d^{-1}. This seep also had the greatest range in flow rates with values from 35 to 931 L d^{-1} and a CV of 99%. In contrast, the seep (4) through a fracture filled with silt loam material had about one forth the flow rate of the open fracture (averaged 111 L d^{-1}) and lower variability with a CV of 77%. The texture of the conductive layer clearly had a significant effect on the flow rate as the seep (6) occurring through a silt loam layer over a restrictive layer had the lowest flow rates which averaged 68 L d^{-1} but the highest variability with CV of 115% of the different type seeps.

The sediment concentrations were even more variable than the flow rates with concentrations ranging by three and half orders of magnitude (Table 2). Surprisingly, seeps (1-3) occurring through a loamy sand (LS) conductive layer over a restrictive layer exhibited the lowest (0.4 g L^{-1}) and the highest (660 g L^{-1}) individual sediment concentrations. Seepage erosion from these seeps exhibited liquefaction of the LS conductive layer with sediment concentrations averaging 246 g L^{-1} and a CV of 93%. The individual sediment concentrations were correlated to the flow rates by a power law relationship, with an r^2 value of 0.68, for the three conductive over restrictive layer seeps combined. Seeps 1 and 3 exhibited high correlations with r^2 values of 0.82, and 0.64, respectively. Seep 2 had the highest flow rates of the three conductive layer seeps, and consistently high sediment concentrations which, as a result, did not exhibit a correlation. In fact, seep 2 had the highest average sediment concentration of all the seeps, Table 2. In contrasts, the seep through a silt loam (SiL) layer over a restrictive layer (seep 6) had similar sediment concentrations to seeps 1-3 but with lower flow rates due to the less conductive material over the restrictive layer (Figure 4). The result was a weak power law relationship (r^2 value of 0.11) for seep 6.

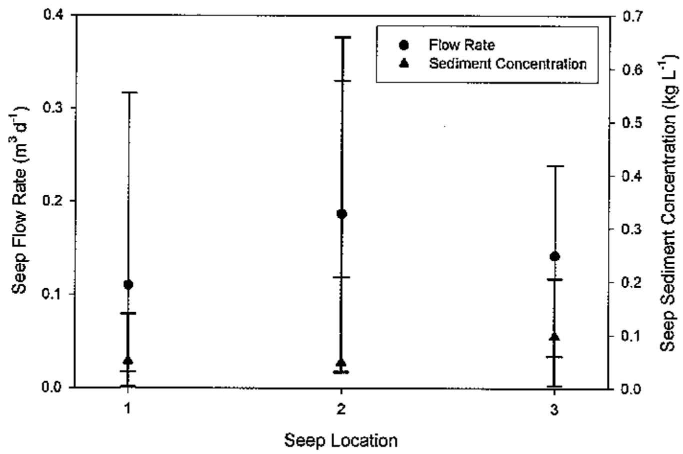

Figure 4 - Flow rate and sediment concentrations measured at selected seep locations along Little Topashaw Creek. Flow rate and sediment concentrations were sampled five times at seep 1, seven times at seep 2, and four times at seep 3.

The second highest mean sediment concentration was for seep 4 which occurred as flow through a fracture that was filled with silt material. As the sediment concentration in seep 4 increased the flow rate was restricted, thereby resulting in a negative relationship to flow rate (negative exponent of -0.2). In contrasts, seep 5 appeared as flow through an open fracture. Seep 5 had the highest flow rates of all seeps but the lowest sediment concentrations. Since this open-fracture seep was supply limited, the higher the flow rate the greater the detachment thereby, producing a high correlation to flow rate (r^2 value of 0.95). It is possible that the seep 5 fractures were filled at some time but the silt had flushed from within their fracture volumes prior to these measurements.

Hydrologic differences among seeps resulted in an overall power law relationship (equation in Figure 4) that had an r^2 value of 0.13, however, if the two high flow rates for seep 5 are omitted as outliers, the overall r^2 increases to 0.28. The high sediment concentrations exhibited by the sapping zone for LS conductive layers over restrictive layers rapidly undercut the overlying soil profiles. Sapping erosion left the soil above unsupported which fostered streambank failure, thereby ending the seep measurements.

Laboratory Lysimeter Experiments

The small lysimeter (40 cm tall) experiments were unable to mimic flow rates observed in the field due to its limited head range at the inflow water reservoir (i.e., 40 cm). Small lysimeter flow rates averaged 0.013 m^3 d^{-1} to 0.037 m^3 d^{-1} for the 0, 5, and 10% slope experiments. However, sediment concentrations due to seepage erosion (1.1-1.3 kg L^{-1}) were higher than concentrations measured in situ due to the inability to mimic macroscopic soil structure due to organic and Fe-oxides that formed interparticle bridges. The small lysimeter was unable to mimic bank failure processes. Bank failure was not consistently observed despite significant undercutting of the bank. A 0% slope experiment failed to produce bank failure by the end of the experiment (60 minutes) while only one of two experiments at the 5% and 10% slopes produced minimal failure. Bank failures occurred prior to the establishment of positive pore water pressures in the SiL, suggesting that bank failure occurred under unsaturated conditions and that bank failure, which has a propensity to occur during the recession limb of hydrographs, may be due more so to interflow seepage erosion than deceased in bank shear strength due to the loss of matrix suction.

The large lysimeter allowed greater inflow water heads which were capable of mimicking hydraulic profiles through relatively thick SiL layers (i.e., 1.5-2.5 m) in the field and therefore seepage erosion, tension crack formation, and bank failure (Figure 5). Discharge in the eight lysimeter experiments averaged 0.12 m^3 d^{-1} with a CV of 46% and was within field measured rates. Seepage erosion rates averaged 1.87 kg L^{-1} with a CV of 16% and were again larger than observed in the field.

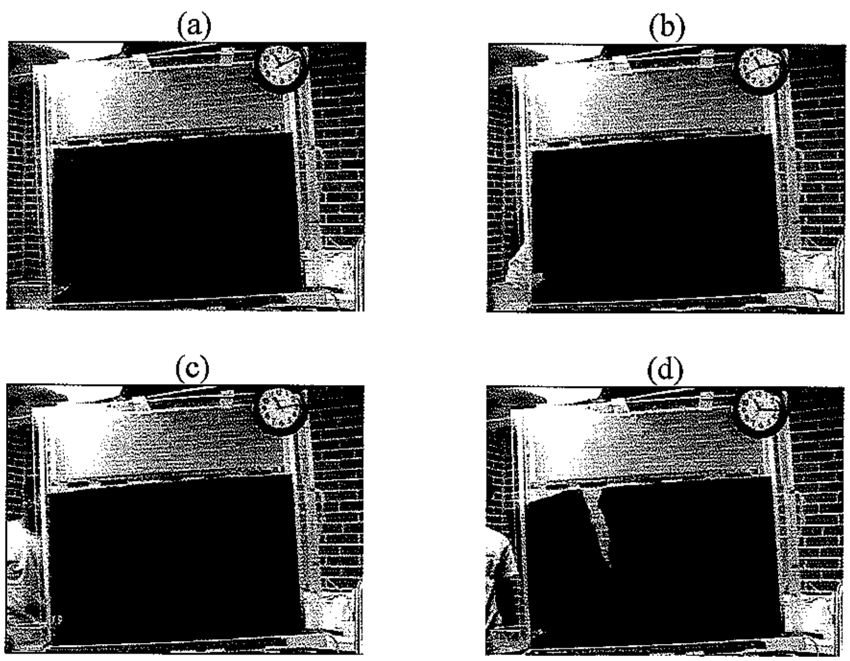

Figure 5 - Typical time series of bank failure of reconstructed streambank profiles due to subsurface erosion: (a) sapping erosion, (b) undermining, (c) tension crack formation, and (d) collapse.

Definitive patterns were observed between bank collapse and perched water table height and bank height (Table 3). Bank failure time correlated to the depth of the perched water table. Bank failure occurred 660, 570, and 300 s after the initiation of the experiment for the 30, 60, and 90 cm inflow water heads, respectively. However, the response of cumulative seepage erosion was inconsistent. Seepage erosion was greater for shallower banks prior to bank failure as expected. Slope insignificantly impacted bank failure time: bank failure occurred at approximately the same time for the 0, 5, and 10% slopes.

Table 3 - Summary of boundary conditions and measured flow and seepage erosion characteristics during the lysimeter experiments.

Boundary Conditions			Lysimeter Measurements					
Bank Height	Water Head	Slope	Time to failure	Seepage Erosion	Tension Crack	Bank Erosion	Undercut	Soil-Water Pressure*
(cm)	(cm)	(%)	(s)	(kg)	(cm)	(kg)	(cm)	(cm H2O)
80	30	0	660	0.53	35.5	24.3	9	-28
80	60	0	570	1.07	21.5	23.1	14	-37
80	90	0	300	0.19	12.4	23.5	4	-33
80	60	5	600	2.20	11.5	7.5	14	-36
80	60	10	645	1.42	32.0	56.3	10	-19
50	60	0	840	3.17	9.0	4.7	13	-29
50	60	5	900	2.00	28.5	33.6	15	-44
50	60	10	1050	3.76	35.0	36.8	28	-22

* Soil-water pressure refers to the pressure reading at Tensiometer 1 (15 cm from streambank face and 30 cm from the bottom of the lysimeter in the SiL) at the end of the experiment (i.e., bank failure time).

Tensiometer data again suggested collapse of the banks prior to the removal of negative pore-water pressures in the SiL (Figure 6). This tensiometer data was modeled using a two-dimensional, variably-saturated ground water flow code: VS2D (Healy, 1990). The model was calibrated based on measured pore-water pressures during the lysimeter experiments with initial values of soil parameters from the field experiments (Figure 7). VS2D also demonstrated that tension cracks formed in streambank sediment where pressures were equivalent to initial starting pressures of -40 to -50 cm H_2O (Figure 8). Researchers have suggested that since the bank angle exceeds critical angles for noncohesive sediment that any flow depth will result in seepage erosion. However, flow depths on the order of 1-4 cm were required to initiate seepage erosion as determined from the calibrated VS2D models. These results suggest that it may not be appropriate to assume LS as noncohesive. Bank undercutting of 15-35 cm was generally required prior to bank failure. Following the suggested hypothesis of Howard and McLane (1988), seepage erosion rate correlated to seepage discharge based on a power law relationship with an average correlation coefficient (r^2) of 0.9. A dimensionless seepage erosion sediment transport model has also been derived based on the dimensionless sediment flux

(q_s*) and shear stress (τ*), where shear stress was assumed to be dependent on the seepage force proposed by Howard and McLane (1988):

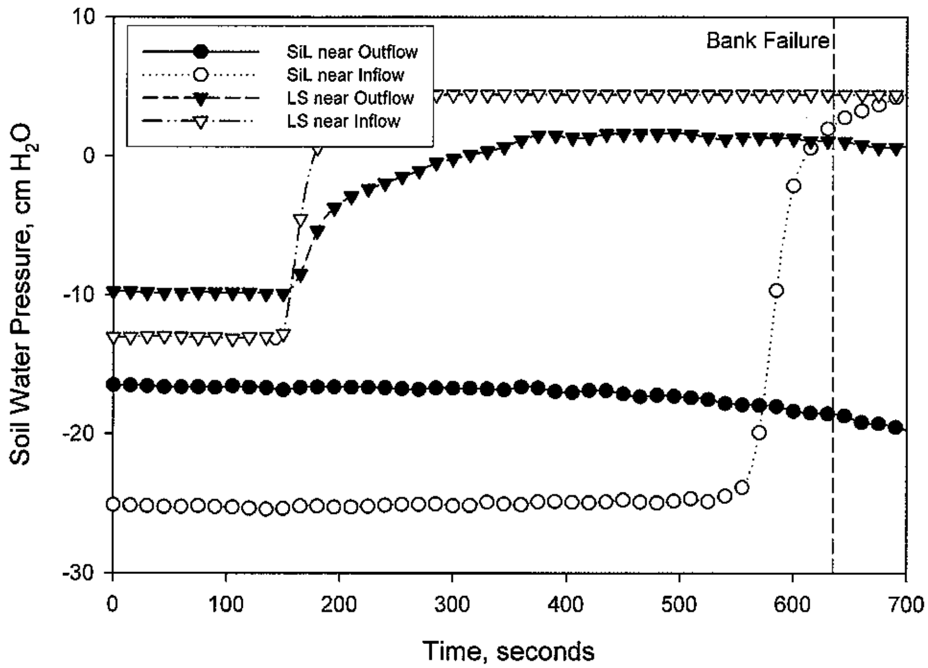

Figure 6 - Typical tensiometer data in loamy sand (LS) and silt loam (SiL) streambank layers. Data shown are for experimental boundary conditions of 80 cm bank height, 60 cm inflow water head, and 10% slope.

$$q_s^* = a\,\tau^{*b} \tag{3}$$

$$q_s^* = \frac{q_s}{\sqrt{(s-1)gd^3}} \tag{4}$$

$$\tau^* = \frac{C_2'' q}{(s-1)nK} \tag{5}$$

where a and b are empirical regression parameters, C_2'' is an empirical parameter that depends on the packing coefficient, q is Darcy's velocity or discharge per unit flow area (assumed equal to the width of the lysimeter times the average flow depth at the lysimeter outlet), K is the hydraulic conductivity, θ is the bank angle, n is the porosity, and s is the ratio of solid to fluid density. Data from the seven lysimeter experiments fit the proposed seepage erosion sediment transport model (a = 584, b = 1.04) with an r^2 of 0.86 (Figure 9). Fox et al. (2005) discuss more details on the development of the seepage erosion sediment transport model and large lysimeter experiments.

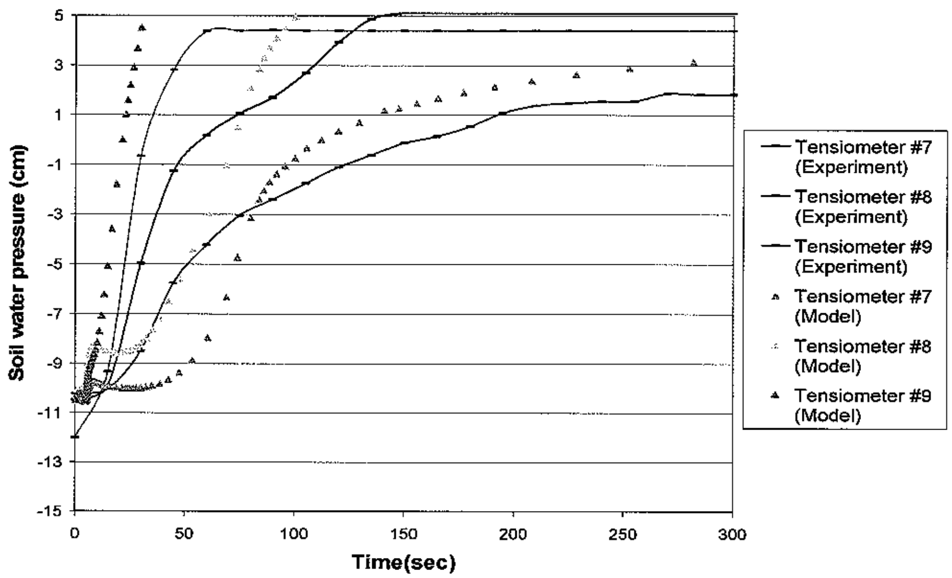

Figure 7 - Comparison of simulated pore-water pressure with tensiometer experimental data within the loamy sand layer for the large lysimeter experiment with 10% slope, 60 cm inflow water head, and 50 cm bank height.

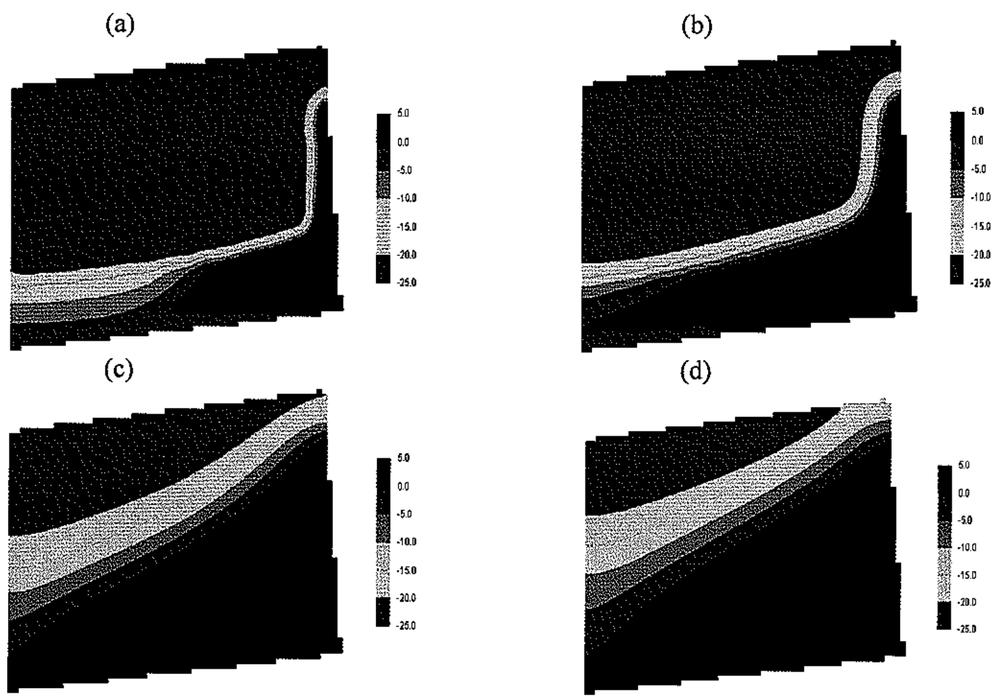

Figure 8 - VS2D predicted pore-water pressures during the 10% slope, 60 cm inflow water head, and 50 cm bank height lysimeter experiment: (a) after 25 s, (b) time to flow, (c) after 500 s, and (d) at bank collapse. Red = -25 cm H_2O, Blue = 5 cm H_2O.

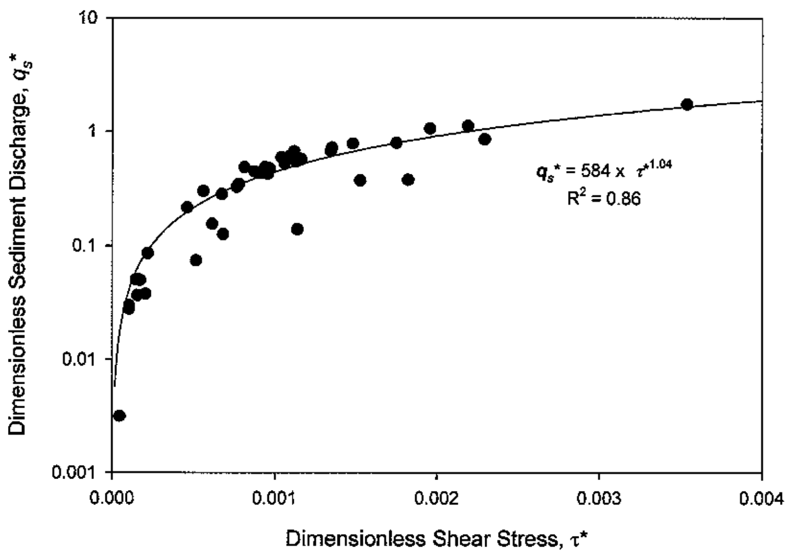

Figure 9 - Dimensionless sediment flux (q_s*) versus dimensionless shear stress (τ*) as measured from the lysimeter experiments.

It has been concluded that further laboratory experimentation is needed to fully explain the soil and hydraulic controls on seepage erosion. Using the large lysimeter, experiments are currently underway with single layered LS by packing 40 cm LS at field measured bulk density. Tensiometers have been repositioned near the outflow face to obtain more detailed information regarding flow depths required to initiate significant seepage erosion. Initial results from these experiments suggest that tensiometer data may be able to detect failures in the single LS layer and therefore provide a clearer picture as to the pore-water pressure profiles at the time of seepage erosion and bank failure. Experiments will also be performed with numerous streambank angles to verify the seepage erosion sediment transport model with slopes ranging from vertical to the critical seepage angles predicted by existing theoretical models.

Streambank Stability Modeling

A static water table would need to be at the soil surface (0 depth) to cause unstable conditions. In contrast, the condition of an unsaturated 30 cm thick top soil but with water perched in a conductive layer below was much more stable. The factor of safety (Fs) prior to establishing a perched head within the conductive layer was 1.65. According to the Streambank Stability model, the bank would remain stable under a 40 cm head, with an Fs value of 1.41. The head would have to reach around 120 cm before the Fs is less than 1. Conditionally stable conditions were predicted to occur under a perched head of around 70 cm and the sediment load predicted to be lost was 20 kg. However, the model failed to account for the sediment load from the sapping zone when the bank remained stable and it over estimated the sediment load when failure did occur. More importantly, when failure was observed it only required a 40 cm head of water perched in the conductive layer as compared to the predicted value of 70 to 120 cm (Wilson et al., 2006).

SUMMARY

This research has indicated the importance of seepage erosion at one streambank site in Northern Mississippi. Seepage erosion rates measured in situ and simulated in the laboratory provided initial evidence as to the potential role of seepage erosion during the recession limbs of stream flow hydrographs. Seepage erosion may play a more important role compared to decreased shear strength due to the loss of matrix suction, especially in layered stream banks. For predicting seepage erosion effects on streambanks, detailed characterization of soil profile lithology is critical for accurate seepage erosion prediction. Future research is aimed towards extending lysimeter studies to simulate in-field streambank conditions, including low-stage seepage erosion and high-stage streambank storage return. Future research will evaluate the empirical sediment transport model. An existing process-based model of stream evolution (CONCEPTS) will be modified in the near future to include seepage erosion. Such a combined model will allow sensitivity analyses to be performed with the model to evaluate the importance of soil, hydraulic, and geotechnical parameters on seepage erosion and mass wasting of banks.

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LIST OF PUBLICATIONS/CONFERENCE PROCEEDINGS

The following is a list of all reports submitted for publication or published as a conference proceedings paper during the reporting period.

Wilson, G.V., R. Periketi, G.A. Fox, S. Dabney, D. Shields, and R.F. Cullum. Seepage erosion properties contributing to streambank failure. *Earth Surface Processes and Landforms* (Accepted with Minor Revisions, February 2006).

Fox, G.A., G.V. Wilson, R.K. Periketi and B.F. Cullum. A sediment transport model for seepage erosion of streambanks. *Journal of Hydrologic Engineering – ASCE* (Accepted with Minor Revisions, February 2006).

Fox, G.A., G.V. Wilson, R. Periketi, and R.F. Cullum. 2005. Developing a sediment transport model for the seepage erosion of streambank sediment. *Proceedings of the American Water Resources Conference*, Nov 7-10th, Seattle, WA, 4 pages (CD-ROM).

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Fox, G.A. 2006. Can Subsurface Flow Erode Streambanks? USDA Cooperative State Research, Education, and Extension Service Water Quality Conference, February 5-9: San Antonio, TX.

Fox, G.A., G.V. Wilson, and R. Periketi. 2005. Simulating the erosion of streambanks by lateral, subsurface flow. 35th Mississippi Water Resources Conference, April 26-27: Jackson, MS.

Fox, G.A., R. Periketi, and G.V. Wilson. 2005. Laboratory simulation and numerical modeling of streambank seepage erosion. 2005 Spring Section Meeting of the Mississippi Section of the American Society of Civil Engineers, Friday, April 22nd, Oxford, MS.

INFORMATION TRANSFER PLAN

Results of this research will be disseminated by the research team through publication in a number of diverse, nationally recognized research journals and by presentation at several interdisciplinary local, state, and national conferences. Two manuscripts have already been submitted for publication as a result of this project. These manuscripts will highlight the importance of considering seepage erosion in streambank stability analysis. We have attempted to make results from this research directly transferable to other agricultural watersheds. This research is also being used by USDA-ARS National Sedimentation Laboratory scientists in conjunction with NSL CEAP activities to assist in developing non-technical fact sheets for distribution to water agencies and landowners.

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